DOCUMENT RESUME

ED 069 785 TM 002 270

AUTHOR	Tinsley, Howard E. A.; Dawis, Rene V.
TITLE	Test-Free Person Measurement with the Rasch Simple Logistic Model.
INSTITUTION	Minnesota Univ., Minneapolis. Dept. of Psychology.
SPONS AGENCY	Office of Naval Research, Washington, D.C. Psychological Sciences Div.
REPORT NO	MU-TR-3006
PUB DATE	25 Jul 72
NOTE	27p.
EDRS PRICE	MF-$0.65 HC-$3.29
DESCRIPTORS	*Ability Identification; College Students; Educational Research; High School Students; Hypothesis Testing; *Mathematical Models; *Measurement Instruments; Statistical Analysis; Tables (Data); Technical Reports; *Test Construction; Testing
IDENTIFIERS	*Rasch Simple Logistic Model

ABSTRACT

This research investigated the use of the Rasch simple logistic model in obtaining test-free ability estimates. Tests employing word, picture, symbol and number analogies were administered to college and high school students. The results show that the Rasch model does not offer an improvement over the use of percentile ranks in estimating individual ability. These results, however, are an artifact of the research design. Shortcomings in the research design, as well as in that used by Wright (1968), are discussed. This paper concludes with the discussion of an appropriate research design for the investigation of this question. (For related document, see TM 002 271.) (Author)

U.S. DEPARTMENT OF HEALTH
EDUCATION & WELFARE
OFFICE OF EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.

ED 069785

DOD
TM

THE CENTER FOR THE STUDY OF ORGANIZATIONAL PERFORMANCE AND HUMAN EFFECTIVENESS

University of Minnesota
Minneapolis, Minnesota

Office of Naval Research Contract
ONR N00014-68-A-0141-0003

TM 002 220

Approved for public release; distribution unlimited

ED 069785

Prepared for

PERSONNEL AND TRAINING RESEARCH PROGRAMS
PSYCHOLOGICAL SCIENCES DIVISION
OFFICE OF NAVAL RESEARCH

Contract No. 00014-68-A-0141-0003
Contract Authority Number, NR. No. 151-323

TEST-FREE PERSON MEASUREMENT WITH THE RASCH SIMPLE LOGISTIC MODEL

Howard E. A. Tinsley and Rene' V. Dawis
University of Minnesota

Technical Report No. 3006

This document has been approved for public release and sale; its distribution is unlimited. Reproduction in whole or in part is permitted for any purpose of the United States Government.

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)	2a. REPORT SECURITY CLASSIFICATION
Department of Psychology University of Minnesota Minneapolis, Minnesota 55455	UNCLASSIFIED 2b. GROUP

3. REPORT TITLE

Test-Free Person Measurement with the Rasch Simple Logistic Model

4. DESCRIPTIVE NOTES (Type of report and, inclusive dates)

Technical Report No. 3006

5. AUTHOR(S) (First name, middle initial, last name)

Howard E A. Tinsley and Rene' V Dawis

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
25 July 1972	16	10

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
N00014-68-A-0141-0003 b. PROJECT NO. NR 151-323 c. d.	3006 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT

Approved for public release: distribution unlimited

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Personnel and Training Research Programs Office of Naval Research Arlington, Virginia 22217

13. ABSTRACT

This research investigated the use of the Rasch simple logistic model in obtaining test-free ability estimates. Tests employing word, picture, symbol and number analogies were administered to college and high school students. The results show that the Rasch model does not offer an improvement over the use of percentile ranks in estimating individual ability. These results, however, are an artifact of the research design. Shortcomings in the research design, as well as in that used by Wright (1968), are discussed This paper concludes with the discussion of an appropriate research design for the investigation of this question.

DD FORM 1 NOV 65 1473 (PAGE 1)

S/N 0101-807-6811

UNCLASSIFIED

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Rasch model						
Simple logistic model						
Test-free person measurement						
Ability						
Ability estimation						
Analogy tests						
Test equivalence						

Test-Free Person Measurement with the Rasch Simple Logistic Model

Howard E. A. Tinsley and Rene' V. Dawis

University of Minnesota

Rasch (1960) has proposed a simple logistic model for tests of intelligence or attainment which hypothesizes that the probability of a correct response to an item is a function of the ability of the person and the difficulty of the item. Rasch has been able to demonstrate mathematically that his model allows the separation and the independent estimation of these two parameters. Thus, in theory, given a set of calibrated items which fit his model, one may calculate ability estimates on the same scale from responses to any subset of items. This means that alternative or partial forms of a test may be scored on a common scale. Comparable scores presumably can be obtained even when the same items were not administered to all subjects, thereby making possible the individualized administration of tests in which only those items relevant to the examinee's ability level are administered. In short, the Rasch simple logistic model makes possible what Wright (1968) has characterized as test-free person measurement. If these claims are substantiated, tests developed in accordance with the Rasch model would represent a marked improvement over tests developed in accordance with classical psychometric theory.

Although introduced in 1960, this aspect of the Rasch simple logistic model has been virtually ignored. Several investigators have studied the use of the model for item calibration (Anderson, Kearney, & Everett, 1968; Brooks, 1965; Rasch, 1960; Tinsley & Dawis, 1972a, 1972b; and Wright, 1968)

but the work of Wright (1968) represents the only investigation the present authors were able to find which attempts to determine whether the model leads to test-free person measurement. Wright's research is based upon the responses of 976 beginning law students to 48 reading comprehension items on the Law School Admission Test. Wright divided the original 48-item test into two sub-tests, one containing the 24 easiest items, the other containing the 24 hardest items. For each subject, Wright calculated his raw score and his Rasch ability estimate on the two tests. He then calculated the difference between the two raw scores and the difference between the two ability estimates, and compared the distribution of the differences for the two types of scores. Wright points out that the distribution of differences for raw scores, with a mean of 6.78 and a standard deviation of 3.30 is almost entirely above zero (see Table 1). On the other hand, the distribution of differences in Rasch ability estimates, with a mean of .061 and a standard deviation of .749, is centered around zero. Wright (1968) concludes that the alternative Rasch ability estimates seem to be in agreement.

Insert Table 1 about here.

Wright goes a step further with the Rasch ability estimates. For each individual, he divides the difference between the two ability estimates by the measurement error of this difference. This produces what Wright calls the distribution of standardized differences with a mean of .003 and a standard deviation of 1.014. Wright concludes from these data that the only variation observed in ability estimates is of the same magnitude as that expected from the standard error of measurement in the test, and that these data support the claim that the Rasch simple logistic model allows the measurement

of a person with any set of calibrated items.

Two problems with this investigation must be noted. First, the results were biased in favor of the Rasch model when Wright chose to summarize the difference between scores on the two tests in terms of the mean. Because the raw scores are all positive, differences in raw scores will all be positive. The Rasch ability estimates are logarithms, however, half of which are negative. Approximately half the differences in logarithmic ability estimates will be negative, with the result that the mean difference in logarithmic ability will be close to zero. Use of the absolute value of the differences would have avoided this problem. The results were further biased in favor of the Rasch model when Wright utilized the standardized difference in the logarithmic ability estimates without doing so for the difference in raw scores. Computation of the mean standardized absolute difference for both types of scores would have been preferable.

The assertion, then, that the Rasch simple logistic model allows test-free person measurement remains largely unsubstantiated. Clearly, this question deserves considerable attention. The purpose of this research was to investigate this claim.

Method

Instruments. Four analogy tests, combined into two test booklets, were utilized in this study. The first test booklet contained a 60-item word analogy test followed by a 40-item symbol analogy test. The second test booklet contained a 60-word number analogy test followed by a 50-item picture analogy test. All items were of the multiple choice type with five response alternatives and with the blank in the item stems distributed among

the four positions. All tests were introduced by one standard page of test instructions.

Subjects. Two samples of subjects were employed in this study. College students enrolled in an introductory psychology class at the University of Minnesota during the Fall of 1970 constituted the first sample. All were volunteers (obtained through the subject pool of the Department of Psychology) who were participating in the research to gain additional points toward their course grade. Some students completed only one of the test booklets while others completed both of them. High school students enrolled in two suburban Twin Cities high schools constituted the second sample. Each student completed one test booklet. In both high schools, the test booklets were completed by students in the classes of those teachers who volunteered to participate in the study.

Because the test forms were designed to be self-explanatory, subjects were simply given the test, instructed to read the directions, and to complete the test. The test administrator was always available, however, to answer any questions. No time limits for completion of the test were set but students in the high schools were allowed only one fifty-minute class period in which to complete the test.

Analysis. The procedure for such an investigation need not be complicated. First a sample of subjects must be administered two tests of the same ability, composed of items which have been calibrated on a common scale. Then, scores on these two tests must be converted to ability estimates on a common scale. These ability estimates should be approximately the same, with errors of measurement accounting for all the differences. Four such comparisons were made in this study, one each with word, picture, number and

symbol analogies. In each case, the sample of high school students and college students was combined. Next, each test was divided into two subtests. The subdivision of the word picture, and symbol analogy tests was straightforward. First, the items in the total test were arranged in the order of their easiness. Then they were divided into two subtests with one subtest containing the hard items, the other the easy items. Because there were so many easy items in the number analogy test, this procedure was amended slightly. After the number analogies had been arranged in order of their easiness, the 25 easiest items were assigned to one subtest. Then items 26 through 35 were assigned to the second subtest. Items 36 through 40 were then assigned to the first subtest and items 41 through 60 were placed in the second subtest. This procedure was necessary because the ceiling on a subtest composed of the thirty easiest number analogies was so low that many subjects would have received perfect scores, necessitating their elimination from the study.

After the tests had been divided into subtests, the raw score, percentile rank, and Rasch ability estimate of each subject was computed for the two subtests. These item characteristics were computed using a program developed by Wright and Panchapakesan (1969,1970) and modified by Bart, Lele, and Rosse (1970) for use on the University of Minnesota CDC 6600 computer. Finally, the product-moment correlation and the mean and standard deviation of the absolute difference between the scores on the two subtests were computed for the raw scores, percentile ranks, and Rasch ability estimates. Support for the hypotheses that the ability estimates are invariant with respect to the easiness of the items in the test would be indicated if the correlation between ability estimates on the two tests approaches unity and the distribution of

the absolute differences between ability estimates on the two tests centers around zero.

In each case, the sample for a given test consisted of those college and high school students who had completed the test, minus those whose score on the total test was lower than the r index recommended by Panchapakesan (1969), and minus those who received a perfect or a zero score on either of the the subtests. The r index is an index suggested for the identification of subjects with scores so low that guessing may have been a factor in determining their ability estimates. Thus, only those subjects for whom guessing was not a factor were included in this analysis. Table 2 indicates the number of examinees excluded from this study and the number remaining.

Insert Table 2 about here.

Results

The invariance of raw scores, percentile ranks, and Rasch ability estimates was investigated. If raw scores differ only by a constant associated with the difference in the difficulty of the test, the correlation between the two sets of raw scores should approach unity and the mean of the distribution of absolute differences should be the constant. But if this is true, conversion of the raw scores to percentile ranks, separately for each subtest, should be an effective method for equating subtest scores. Accordingly, the correlation between the two sets of percentile ranks should also approach unity, but the mean of the distribution of absolute differences in the subtest percentile rank scores should approach zero. In practice, however, the above result is seldom observed. Scores differ by a variable rather than a constant amount. Measurement by the Rasch model supposedly avoids this

problem. Since the items in the subtests were calibrated on a common scale, the Rasch ability estimates from the two subtests should be on a common scale. This means that there should be no difference in the scores of the two subtests. The correlation between scores on the two subtests should approach unity and the mean of the distribution of absolute differences in scores should approach zero.

Table 3 gives the correlations between the scores on the four types of subtests. The highest correlations were observed between scores on the word analogy subtests, with raw scores and percentile ranks correlating .68 and Rasch ability estimates correlating .67. Intermediate correlations were observed for the picture and number analogy subtests. For the picture analogies, raw scores correlated .47, percentile ranks correlated .50, and Rasch ability estimates correlated .48; the corresponding correlations for number analogies were .47, .51, and .51. The lowest correlations occured for symbol analogies. Raw scores correlated .27, percentile ranks correlated .30, and Rasch ability estimates correlated .27.

Insert Table 3 about here

Table 4 indicates the mean and standard deviation of the distribution of absolute differences in subtest scores for each of the four tests. The mean difference in raw scores ranged from 9.25 for symbol analogies to 12.56 for number analogies with the mean varying between 3.0 and 3.5 standard deviations above zero. The mean differences in percentile ranks were .18 for word analogies, .22 for number and picture analogies, and .27 for symbol analogies, and varied between 1.2 and 1.3 standard deviations above zero. The mean differences in Rasch ability estimates were .55 and .57 for

word and picture analogies, .72 and .73 for number and symbol analogies, and, like the mean differences for percentile ranks, vary between 1.2 and 1.3 standard deviations above zero.

Insert Table 4 about here.

Discussion

One of the most promising features of the Rasch model is that it would make possible the individualization of measurement. Once a pool of items calibrated on a common scale has been developed, individuals need complete only those items appropriate to their ability level and their scores can be converted to ability estimates on a common scale. This means that the scores of the individuals can be compared even if the tests they completed do not have one single item in common. It was with this feature of the Rasch model that this research was concerned.

This research investigated the hypotheses that raw scores, percentile ranks and Rasch ability estimates are invariant with respect to the items used in measurement. The data indicate that there is little difference among the three ability measures; all three are dependent upon the items used in measurement. However, this finding is misleading--a reflection of the inadequacy of the research design. In the first place, it is illogical to assume that tests which do not fit the Rasch model will still have the characteristics attributed to it. Only one of the eight subtests used in this research had a Rasch maximum likelihood probability greater than .05. The probability of the easy picture subtest was .03 and the probability of the hard symbol subtest was .44. The maximum likelihood of the remaining six subtests was less than .001. There is no reason, therefore, to expect that

results based on these tests will possess the properties of the Rasch model.

Another problem with this research design concerns the method of administering the test questions. The goal of the Rasch model is to measure the individual as accurately as possible. The precision of the measurement depends on the number of items used in the measurement and the appropriateness of the items for the ability of the examinee (Panchapakesan, 1969). If the use of the Rasch model is to lead to more precise measurement, the standardized method of item presentation in which each examinee answers every question must be abandoned. Take, for example, the case of a low ability subject. Many of the items on the easy subtest were no doubt appropriate for measuring his ability. It is even possible that his ability was rather precisely estimated in this subtest. In contrast, most of the questions on the hard subtest were inappropriate for this examinee. Each of the questions gave very little information about his ability and the resulting ability extimate was based upon very little information. Consequently, the two ability estimates would have very little chance of agreeing.

If the research design for this study is inappropriate, how is it that Wright (1968) achieved satisfactory results using essentially the same design? It has already been suggested that Wright analyzed his data incorrectly. Wright reported the mean and standard deviation of the distribution of differences, where the mean and standard deviation of the absolute differences would have been more appropriate. Table 5 presents the means and standard deviations of the distributions of signed differences for the data reported in this study. The results represent Wright's (1968) method of analysis and can be compared with those presented in Table 4. The results for word, picture, and symbol analogies, when looked at in this manner, compare favorably

with those reported by Wright (see Table 1.) Wright (1968, pp. 95-96) interprets his results as indicating that the Rasch simple logistic model yields item-free person measurement. It has been shown, however, that these results are artifacts of the method of analysis employed.

Insert Table 5 about here.

The research design, then, was inappropriate for testing the hypothesis that Rasch ability estimates are invariant with respect to the items used in measurement. A successful test of this hypothesis requires a procedure for the individualized administration of items. Subtests could be constituted from odd-numbered vs. even-numbered items, after ordering all items according to easiness. A stringest test of the hypothesis could still be obtained by estimating an individual's ability on two subtests, one consisting of largely inappropriate items (e.g., very easy items), the other consisting of items appropriate to the ability of the examinee. In both cases, testing would continue until a specified precision of measurement was achieved. If the hypothesis is supported, the two ability estimates would be identical within the limits of error allowed by the precision of measurement.

References

1. Anderson, J., Kearney, G. E., and Everett, A. V. An evaluation of Rasch's structural model for test items. The British Journal of Mathematical and Statistical Psychology, 1968, 21, 231-238.

2. Bart, W. H., Lele, K., and Rosse, R. Item analysis by the Rasch model. Minneapolis, Minnesota: Department of Psychological Foundations of Education, 1970.

3. Brooks, R. D. An empirical investigation of the Rasch ratio-scale model for item difficulty indexes. (Doctoral dissertation, University of Iowa). Ann Arbor, Mich,: University Microfilms, 1965, No. 65-434.

4. Panchapakesan, N. The simple logistic model and mental measurement. Unpublished Doctoral dissertation, University of Chicago, 1969.

5. Rasch, G. Probabilistic Models for Some Intelligence and Attainment Tests. Copenhagen: Danish Institute for Educational Research, 1960.

6. Tinsley, H. E. A., and Dawis, R. V. A comparison of the Rasch item probability with three common item characteristics as criteria for item selection. Technical Report No. 3003, January, 1972a, Project No. NR151-323, Personnel and Training Research Programs, Office of Naval Research.

7. Tinsley, H. E. A., and Dawis, R. V. An investigation of the Rasch simple logistic model: Sample-free item and test calibration. Technical Report No. 3005, July, 1972b, Project No. NR151-323, Personnel and Training Research Programs, Office of Naval Research.

8. Wright, B. Sample-free test calibration and person measurement. Proceedings of the 1967 Invitational Conference on Testing Problems. Princeton, N J.: Educational Testing Service, 1968. Pp. 85-101.

9. Wright, B., and Panchapakesan, N. A procedure for sample-free item analysis. Educational and Psychological Measurement, 1969,29,23-48.

10. Wright, B., and Panchapakesan, N. Item Analysis by the Rasch Model, UCSL801. Chicago: University of Chicago Computation Center, Social Science Program Library, 1970.

Table 1

Mean, Standard Deviation of Differences in Scores
on Easy and Hard Tests
(N = 976)

Ability Estimate	Mean	Standard Deviation
Raw scores	6.78	3.30
Rasch	.061	.749

Table 2

Sample Size

Analogy Test	Initial Sample	Reasons for Deletion: Low Total Score	Reasons for Deletion: Perfect Subtest Score	Final Sample
Word	949	62	22	865
Picture	612	14	8	590
Number	626	36	10	580
Symbol	938	83	21	834

Table 3

Coorelation of Subtest Scores

Ability Estimate	Analogy Test			
	Word	Picture	Number	Symbol
Raw Score	.68	.47	.47	.27
Percentile Rank	.68	.50	.51	.30
Rasch	.67	.48	.51	.27

Table 4

Mean, Standard Deviation of Absolute Differences in Subtest Scores

Ability Estimate	Analogy Test			
	Word	Picture	Number	Symbol
Raw Scores	10.14± 3.35	10.43±2.97	12.56±3.70	9.25±2.92
Percentile Rank	.18± .15	.22± .18	.22± .18	.27± .21
Rasch	.55± .42	.57± .47	.72± .57	.73± .56

Table 5

Mean, Standard Deviation of Signed Differences
in Subtest Scores

Ability Estimate	Analogy Test			
	Word	Picture	Number	Symbol
Raw Scores	10.14±3.36	10.42±3.00	12.55±3.76	9.24±2.95
Percentile Rank	.007±.238	.003±.288	.017±.286	-.008±.343
Rasch	.047±.696	.094±.733	.196±.901	.038±.916

DISTRIBUTION LIST

NAVY

4 Director, Personnel and Training Research Programs
Office of Naval Research
Arlington, VA 22217

1 Director
ONR Branch Office
495 Summer Street
Boston, MA 02210

1 Director
ONR Branch Office
1030 East Green Street
Pasadena, CA 91101

1 Director
ONR Branch Office
536 South Clark Street
Chicago, IL 60605

1 Commander
Operational Test and Evaluation Force
U.S. Naval Base
Norfolk, VA 23511

6 Director
Naval Research Laboratory
Code 2627
Washington, DC 20390

12 Defense Documentation Center
Cameron Station, Building 5
5010 Duke Street
Alexandria, VA 22314

1 Chairman
Behavioral Science Department
Naval Command and Management Division
U.S. Naval Academy
Luce Hall
Annapolis, MD 21402

1 Chief of Naval Air Training
Code 017
Naval Air Station
Pensacola, FL 32508

1 Chief of Naval Training
Naval Air Station
Pensacola, FL
ATTN: CAPT Allen E. McMichael

1 Chief of Naval Technical Training
Naval Air Station Memphis (75)
Millington, TN 38054

1 Chief
Bureau of Medicine and Surgery
Code 513
Washington, DC 20390

1 Chief
Bureau of Medicine and Surgery
Research Division (Code 713)
Department of the Navy
Washington, DC 20390

1 Commandant of the Marine Corps
(Code A01M)
Washington, DC 20380

1 Commander Naval Air Reserve
Naval Air Station
Glenview, IL 60026

1 Commander
Naval Air Systems Command
Navy Department, AIR-413C
Washington, DC 20360

1 Commander
Submarine Development Group Two
Fleet Post Office
New York, NY 09501

1 Commanding Officer
Naval Medical Neuropsychiatric Research Unit
San Diego, CA 92152

1 Commanding Officer
Naval Personnel and Training Research Laboratory
San Diego, CA 92152

1 Head, Personnel Measurement Staff
Capital Area Personnel Service Office
Ballston Tower No. 2, Room 1204
801 N. Randolph Street
Arlington, VA 22203

1 Program Coordinator
Bureau of Medicine and Surgery (Code 71G)
Department of the Navy
Washington, DC 20390

1 Research Director, Code 06
Research and Evaluation Department
U.S. Naval Examining Center
Building 2711 - Green Bay Area
Great Lakes, IL 60088
ATTN: C.S. Winiewicz

1 Superintendent
Naval Postgraduate School
Monterey, CA 93940
ATTN: Library (Code 2124)

1 Technical Director
Naval Personnel Research and
Development Laboratory
Washington Navy Yard
Building 200
Washington, DC 20390

1 Technical Director
Personnel Research Division
Bureau of Naval Personnel
Washington, DC 20370

1 Technical Library (Pers-11B)
Bureau of Naval Personnel
Department of the Navy
Washington, DC 20360

1 Technical Library
Naval Ship Systems Command
National Center
Building 3 Room 3
S-08
Washington, DC 20360

1 Technical Reference Library
Naval Medical Research Institute
National Naval Medical Center
Bethesda, MD 20014

1 COL George Caridakis
Director, Office of Manpower Utilization
Headquarters, Marine Corps (A01H)
MCB
Quantico, VA 22134

1 Special Assistant for Research
and Studies
OASN (M-RA)
The Pentagon, Room 4E794
Washington, DC 20350

1 Mr. George N. Graine
Naval Ship Systems Command
(SHIPS 03H)
Department of the Navy
Washington, DC 20360

1 CDR Richard L. Martin, USN
CONFAIRMIRAMAR F-14
MAS Miramar, CA 92145

1 Mr. Lee Miller (AIR 413E)
Naval Air Systems Command
5600 Columbia Pike
Falls Church, VA 22042

1 Dr. James J. Regan
Code 55
Naval Training Device Center
Orlando, FL 32813

1 Dr. A. L. Slafkosky
Scientific Advisor (Code Ax)
Commandant of the Marine Corps
Washington, DC 20380

1 LCDR Charles J. Theisen, Jr., MSC, USN
CSOT
Naval Air Development Center
Warminster, PA 18974

ARMY

1 Behavioral Sciences Division
Office of Chief of Research and
Development
Department of the Army
Washington, DC 20310

1 U.S. Army Behavior and Systems Research Laboratory
Rosslyn Commonwealth Building, Room 239
1300 Wilson Boulevard
Arlington, VA 22209

1 Director of Research
U.S. Army Armor Human Research Unit
ATTN: Library
Building 2422 Morade Street
Fort Knox, KY 40121

1 COMMANDANT
U.S. Army Adjutant General School
Fort Benjamin Harrison, IN 46216
ATTN: ATSAG-EA

1 Commanding Officer
ATTN: LTC Montogomery
USACDC - PASA
Ft. Benjamin Harrison, IN 46249

1 Director
Behavioral Sciences Laboratory
U.S. Army Research Institute of Environmental Medicine
Natick, MA 01760

1 Commandant
United States Army Infantry School
ATTN: ATSIN-H
Fort Benning, GA 31905

1 Army Motivation and Training Laboratory
Room 239
Commonwealth Building
1300 Wilson Boulevard
Arlington, VA 22209

1 Armed Forces Staff College
Norfolk, VA 23511
ATTN: Library

1 Mr. Edmund Fuchs
BESRL
Commonwealth Building, Room 239
1320 Wilson Boulevard
Arlington, VA 22209

AIR FORCE

1 Dr. Robert A. Bottenber,
AFHRL/PHS Lackland AFB
Texas 78236

1 AFHRL (TR/Dr. G.A. Eckstrand)
Wright-Patterson Air Force Base
Ohio 45433

1 AFHRL (TRT/Dr. Ross L. Morgan)
Wright-Patterson Air Force Base
Ohio 45433

1 AFHRL/MD
701 Prince Street
Room 200
Arlexandria, VA 22314

1 AFOSR (NL)
1400 Wilson Boulevard
Arlington, VA 22209

1 COMMANDANT
USAF School of Aerospace Medicine
ATTN: Aeromedical Library (SCL-4)
Brooks AFB,TX 78235

1 Personnel Research Division
AFHRL
Lackland Air Force Base
San Antonio, TX 78236

1 Headquarters, U.S. Air Force
Chief, Personnel Research and Analysis Division (AF/SPXY)
Washington, DC 20330

1 Research and Analysis Division
AF/DPXYR
Washington, DC 20330

1 CAPT Jack Thorpe USAF
Dept. of Psychology
Bowling Green State University
Bowling Green, OH 43403

DOD

1 Mr. Joseph J. Cowan, Chief
Psychological Research Branch (P-1)
U.S. Coast Guard Headquarters
400 Seventh Street, SW
Washington, DC 20590

1 Dr. Ralph R. Canter
Director for Manpower Research
Office of Secretary of Defense
The Pentagon, Room 3C980

OTHER GOVERNMENT

1 Dr. Alvin E. Goins, Chief
Personality and Cognition Research Section
Behavioral Sciences Research Branch
National Institute of Mental Health
5600 Fishers Lane
Rockville, MD 20852

1 Dr. Andrew R. Molnar
Computer Innovation in Education Section
Office of Computing Activities
National Science Foundation
Washington, DC 20550

1 Dr. Lorraine D. Eyde
Bureau of Intergovernmental Personnel Programs
Room 2519
U.S. Civil Service Commission
1900 E. Street, NW
Washington, DC 20415

1 Office of Computer Information
Center for Computer Sciences and Technology
National Bureau of Standards
Washington, DC 20234

MISCELLANEOUS

1 Dr. Scarvia Anderson
Executive Director for Special Development
Educational Testing Service
Princeton, NJ 08540

1 Professor John Annett
The Open University
Waltonteale, BLETCHLEY
Bucks, ENGLAND

1 Dr. Richard C. Atkinson
Department of Psychology
Stanford University
Stanford, CA 94305

1 Dr. Bernard M. Bass
University of Rochester
Management Research Center
Rochester, NY 14627

1 Dr. David G. Howers
Institute for Social Research
University of Michigan
Ann Arbor, MI 48106

1 Dr. Kenneth E. Clark
University of Rochester
College of Arts and Sciences
River Campus Station
Rochester, NY 14627

1 Dr. Rene' V. Dawis
Department of Psychology
324 Elliott Hall
University of Minnesota
Minneapolis, MN 55455

1 Dr. Robert Dubin
Graduate School of Administration
University of California
Irvine, CA 92664

1 ERIC
Processing and Reference Facility
4833 Rugby Avenue
Bethesda, MD 20014

1 Dr. Victor Fields
Department of Psychology
Montgomery College
Rockville, MD 20850

1 Mr. Paul P. Foley
Naval Personnel Research and Developmt Laboratory
Washington Navy Yard
Washington, DC 20390

1 Dr. Robert Glaser
Learning Research and Development Center
University of Pittsburgh
Pittsburgh, PA 15213

1 Dr. Albert S. Glickman
American Institutes for Research
3555 Sixteenth Street
Silver Spring, MD 20919

1 Dr. Bert Green
Department of Psychology
Johns Hopkins University
Baltimore, MD 21218

1 Dr. Duncan N. Hansen
Center for Computer-Assisted Instruction
Florida State University
Tallahassee, FL 32306

1 Dr. Richard S. Hatch
Decision Systems Associates, Inc.
11428 Rockville Pike
Rockville, MD 20852

1 Dr. M.D. Havron
Human Systems Associates, Inc.
Westgate Industrial Park
770 Old Springhouse Road
McLean, VA 22101

1 Human Resources Research Organization
Division #3
Post Office Box 5787
Presidio of Monterey, CA 93940

1 Human Resources Research Organization
Division #4, Infantry
Post Office Box 2086
Fort Benning, GA 31905

1 Human Resources Research Organization
Division #5, Air Defense
Post Office Box 6057
Fort Bliss, TX 79916

1 Library
HumRRO Division Number 6
P.O. Box 428
Fort Rucker, AL 36360

1 Dr. Lawrence B. Johnson
Lawrence Johnson and Associates, Inc.
2001 "S" Street, NW
Suite 502
Washington, DC 20009

1 Dr. Norman J. Johnson
Associate Professor of Social Policy
School of Urban and Public Affairs
Carnegie-Mellon University
Pittsburgh, PA 15213

1 Dr. Roger A. Kaufman
Graduate School of Human Behavior
U.S. International University
8655 E. Pomerada Road

1 Dr. Frederick M. Lord
Educational Testing Service
Princeton, NJ 08540

1 Dr. E.J. McCormick
Department of Psychological Sciences
Purdue University
Lafayette, IN 47907

1 Dr. Robert R. Mackie
Human Factors Research, Inc.
Santa Barbara Research Park
6780 Cortona Drive
Goleta, CA 93017

1 Dr. Stanley M. Nealy
Department of Psychology
Colorado State University
Fort Collins, CO 80521

1 Mr. Luigi Petrullo
2431 North Edgewood Street
Arlington, VA 22207

1 Dr. Robert D. Pritchard
Assistant Professor of Psychology
Purdue University
Lafayette, IN 47907

1 Psychological Abstracts
American Psychological Association
1200 Seventeenth Street, NW
Washington, DC 20036

1 Dr. Diane M Ramsey-Klee
R-K Research & System Design
3947 Fidgemont Drive
Malibu, CA 90265

1 Dr. Joseph W. Rigney
Behavioral Technology Laboratories
University of Southern California
3717 South Grand
Los Angeles, CA 90007

1 Dr. Leonard L. Rosenbaum, Chairman
Department of Psychology
Montgomery College
Rockville, MD 20850

1 Dr. George E. Rowland
Rowland and Company, Inc.
Post Office Box 61
Haddonfield, NJ 08033

1 Dr. Benjamin Schneider
Department of Psychology
University of Maryland
College Park, MD 20742

1 Dr. Arthur I. Siegel
Applied Psychological Services
Science Center
404 East Lancaster Avenue
Wayne , PA 19087

1 Dr. Henry Solomon
George Washington University
Department of Ecomomics
Washington, DC 20006

1 Dr. David Weiss
University of Minnesota
Department of Psychology
Elliott Hall
Minneapolis, MN 55455